BIAS IN $PM_{2.5}$ FILTER-BASED METHODS

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Shelly Eberly
Geometric Tools, LLC

Mike McCarthy
Sonoma Technology, Inc.

Some Bias Basics

- Bias estimated by

$$\frac{SLTValue - PEPValue}{PEPValue} * 100$$

  - SLTValue is concentration from sampler operated by state, local, or tribal organization.
  - PEPValue is concentration from sampler operated by Performance Evaluation Program auditor.

- $PM_{2.5}$ bias Data Quality Objective (DQO):

  Average bias over three-year period should be between -10% and +10%

- In 2006, the number of bias pairs required within each organization changed from % of number of samplers to a fixed number, resulting in 40% reduction in number of bias pairs.

$PM_{2.5}$ is particulate matter that is 2.5 micrometers in diameter and smaller.

Bias Questions

1. What are current levels of bias?
2. Has bias been changing over time?
3. When did bias start trending down?
4. Does bias vary by type of separator, WINS versus Very Sharp Cut Cyclone (VSCC)?
5. Does bias vary by season?
6. Does bias vary by region of the country?
7. Does bias vary by $PM_{2.5}$ concentration?

Question 1 – What Are Current Levels of Bias?

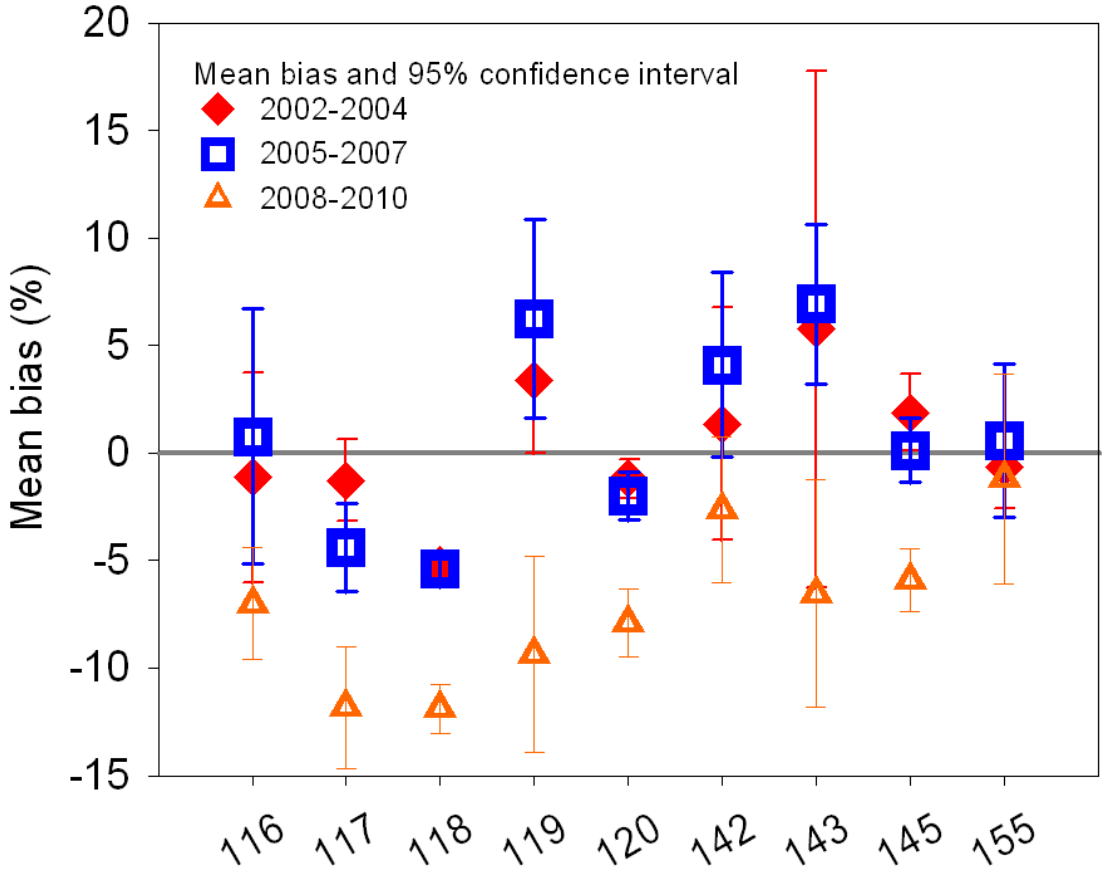
2008-2010 average bias estimates are all negative.

Method Number	Maker	Single / Sequential	WINS / VSCC	Bias (%)	90% Confidence
116	BGI	Single	WINS	-7.8 %	±3 %
117	R&P	Single	WINS	-12.4 %	±3 %
118	R&P	Sequential	WINS	-11.8 %	±1 %
119	Andersen	Single	WINS	-10.7 %	±7 %
120	Andersen	Sequential	WINS	-8.0 %	±1 %
142	BGI	Single	VSCC	-2.0 %	±3 %
143	R&P	Single	VSCC	-6.0 %	±4 %
145	R&P	Sequential	VSCC	-5.9 %	±1 %
153	Thermo	Single	VSCC	-6.1 %	±2 %
155	Thermo	Sequential	VSCC	-3.7 %	±7 %

FINE PRINT
PQAO-Season bias estimates.
Estimates based on pairs > 3 µg/m^3.
Excludes |% diff| > 50%.
Excludes SLTValues =0 µg/m^3.

Question 2 – Has Bias Been Changing Over Time?

Yes. Biases for 2002-2004 and 2005-2007 are similar. Biases for 2008-2010 markedly down across all sampler types, down 8% on average compared to 2005-2007.

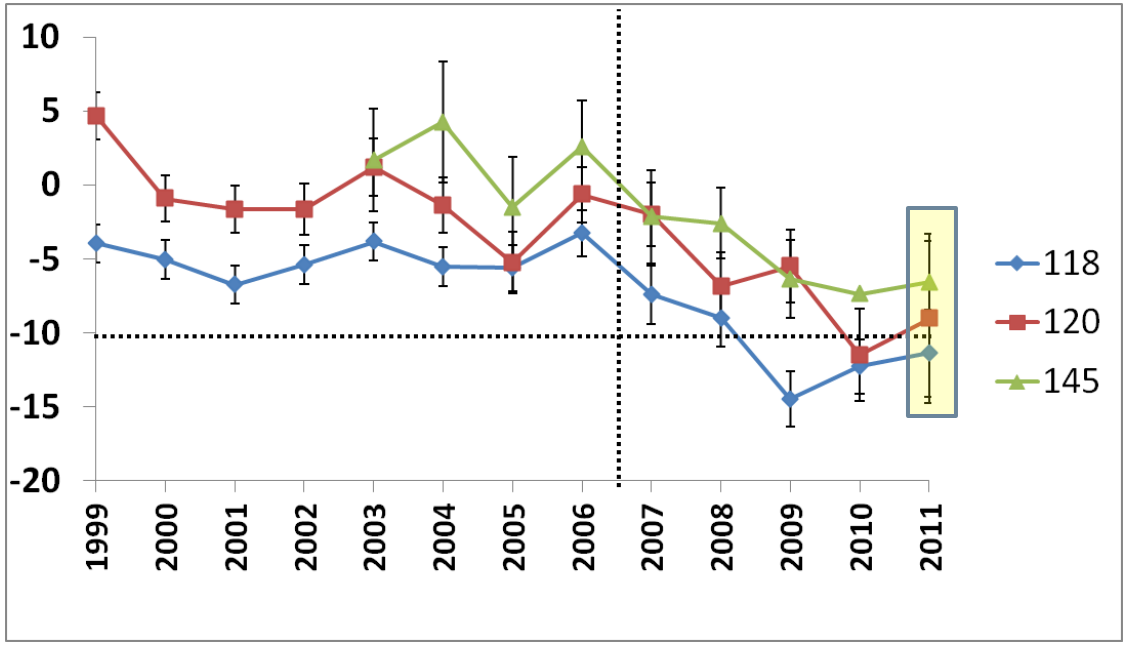


Method Number	Maker	Single / Sequential	WINS / VSCC
116	BGI	Single	WINS
117	R&P	Single	WINS
118	R&P	Sequential	WINS
119	Andersen	Single	WINS
120	Andersen	Sequential	WINS
142	BGI	Single	VSCC
143	R&P	Single	VSCC
145	R&P	Sequential	VSCC
155	Thermo	Sequential	VSCC

FINE PRINT
Monitor-level bias estimates.
Estimates based on pairs > 3 μg/m^3.
Excludes |% diff| > 50%.

Question 3 – When Did Bias Start Trending Down?

Downward trend started in 2007 for most types of samplers. (Graph of three main methods.)



Method Number	Maker	Single / Sequential	WINS / VSCC
118	R&P	Sequential	WINS
120	Andersen	Sequential	WINS
145	R&P	Sequential	VSCC

2011 Estimates Are Preliminary

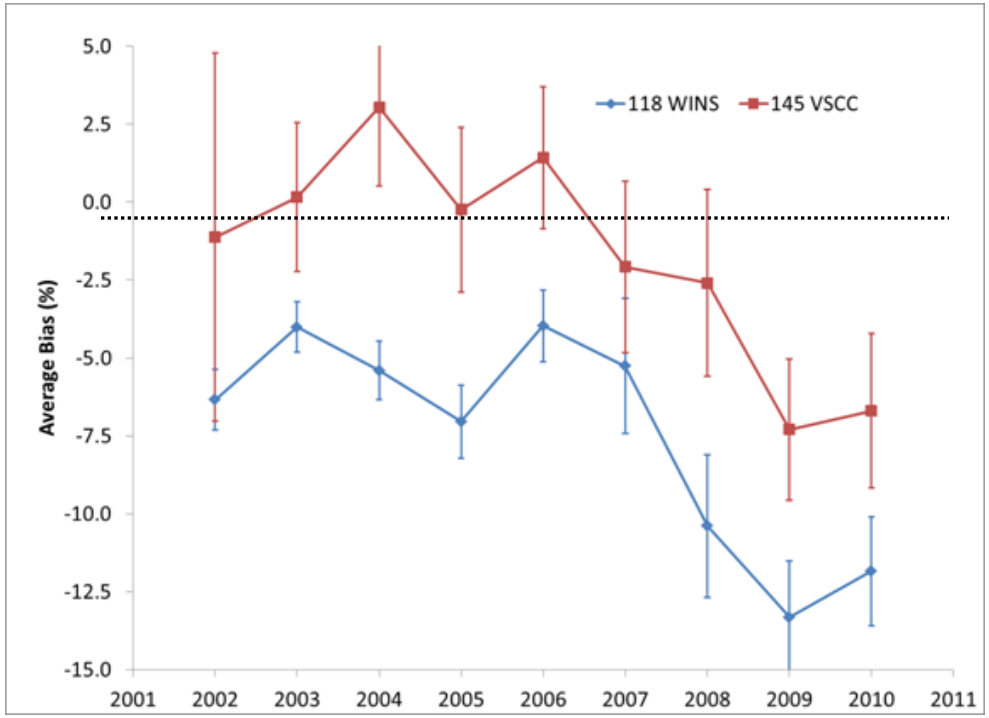
FINE PRINT

PQAO-Season bias estimates.
Estimates based on pairs > 3 µg/m^3.
Excludes |% diff| > 50%.
Excludes SLTValues = 0 µg/m^3.

Question 4 – Does Bias Vary by Type of Separator for SLT?

Yes. When there are sufficient data, bias from WINS is more negative than bias from VSCC.

Sampler Type	Method Numbers	Difference in WINS and VSCC Median Biases	Statistical Test of WINS Bias to VSCC Bias for SLT
BGI Single	116 vs. 142	-7.4 %	WINS Bias < VSCC Bias
R&P Single	117 vs. 143	-9.2 %	WINS Bias < VSCC Bias
R&P Sequential	118 vs. 145	-4.5 %	WINS Bias < VSCC Bias
Andersen Single	119 vs. 153	-0.3 %	Not significantly different.
Andersen Sequential	120 vs. 155	-6.8 %	Not significantly different. Too few observations for 155.



FINE PRINT

Graph is for Monitor-level bias estimates, excludes |% diff| > 50%.

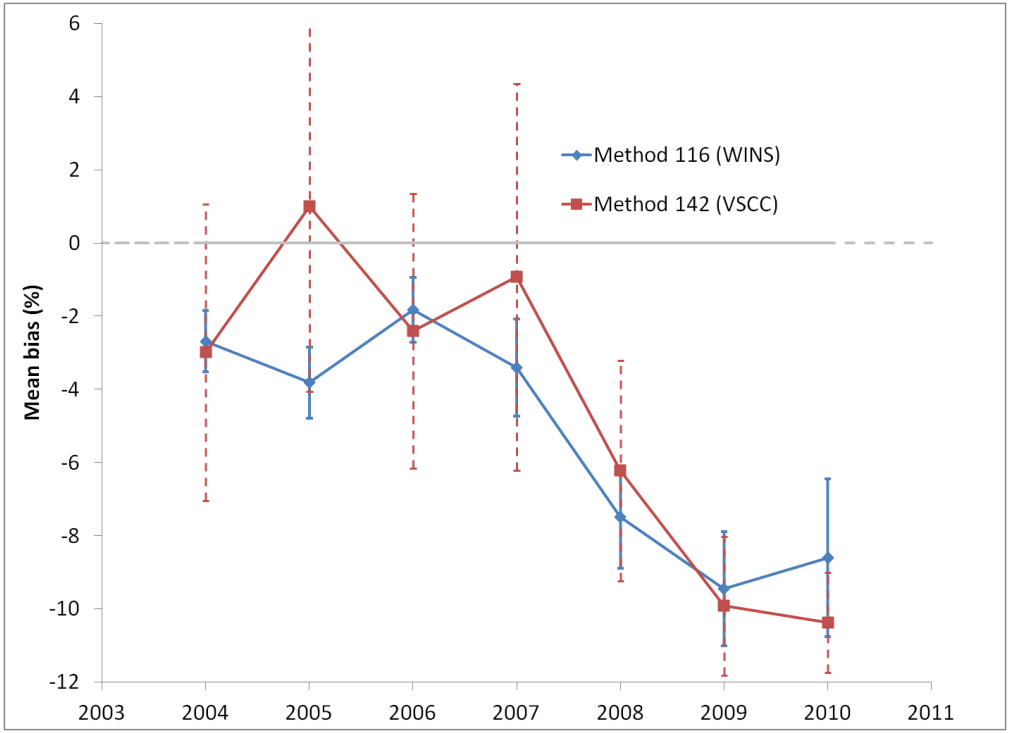
Statistical results based on Mann-Whitney Test of

PQAO-season bias estimates, excludes |% diff| > 50%, excludes SLTValue=0, based on 2008-2010 data, based on pairs > 3 $\mu g/m^3$, test at alpha=0.10.

Question 4 – Does Bias Vary by Type of Separator for PEP?

No. When PEP operates BGI single channel, bias does not differ by separator.

Sampler Type	Method Numbers	Difference in WINS and VSCC Median Biases	Statistical Test of WINS Bias to VSCC Bias for PEP
BGI Single	**116 vs. 142**	**0.2 %**	**Not significantly different.**



FINE PRINT

Graph is for Monitor-level bias estimates, excludes |% diff| > 50%, contains 2008-2010 data only, is for pairs > 3 µg/m^3.

Statistical results based on Mann-Whitney Test of

PQAO-season bias estimates, excludes |% diff| > 50%, excludes SLTValue=0, contains 2009-2010 data only, excludes pairs <= 3 µg/m^3, uses SLT methods (118,120,145) only, test at alpha=0.10.

Question 5 – Does Bias Vary by Season?

YES. 2008-2010 biases show strong seasonality. Summer has most negative bias. Winter usually has least negative bias.

Method Number	Maker	Single / Sequential	WINS / VSCC	Season	Bias (%)	90% Confidence
118	R&P	Sequential	WINS	Spring	-9.2 %	±2 %
				Summer	-12.2 %	±2 %
				Fall	-12.8 %	±2 %
				Winter	-14.0 %	±3 %
120	Andersen	Sequential	WINS	Spring	-9.3 %	±3 %
				Summer	-11.4 %	±3 %
				Fall	-7.1 %	±3 %
				Winter	-2.0 %	±3 %
145	R&P	Sequential	VSCC	Spring	-4.8 %	±3 %
				Summer	-10.5 %	±3 %
				Fall	-5.1 %	±3 %
				Winter	-3.0 %	±3 %

FINE PRINT

PQAO-Season bias estimates.

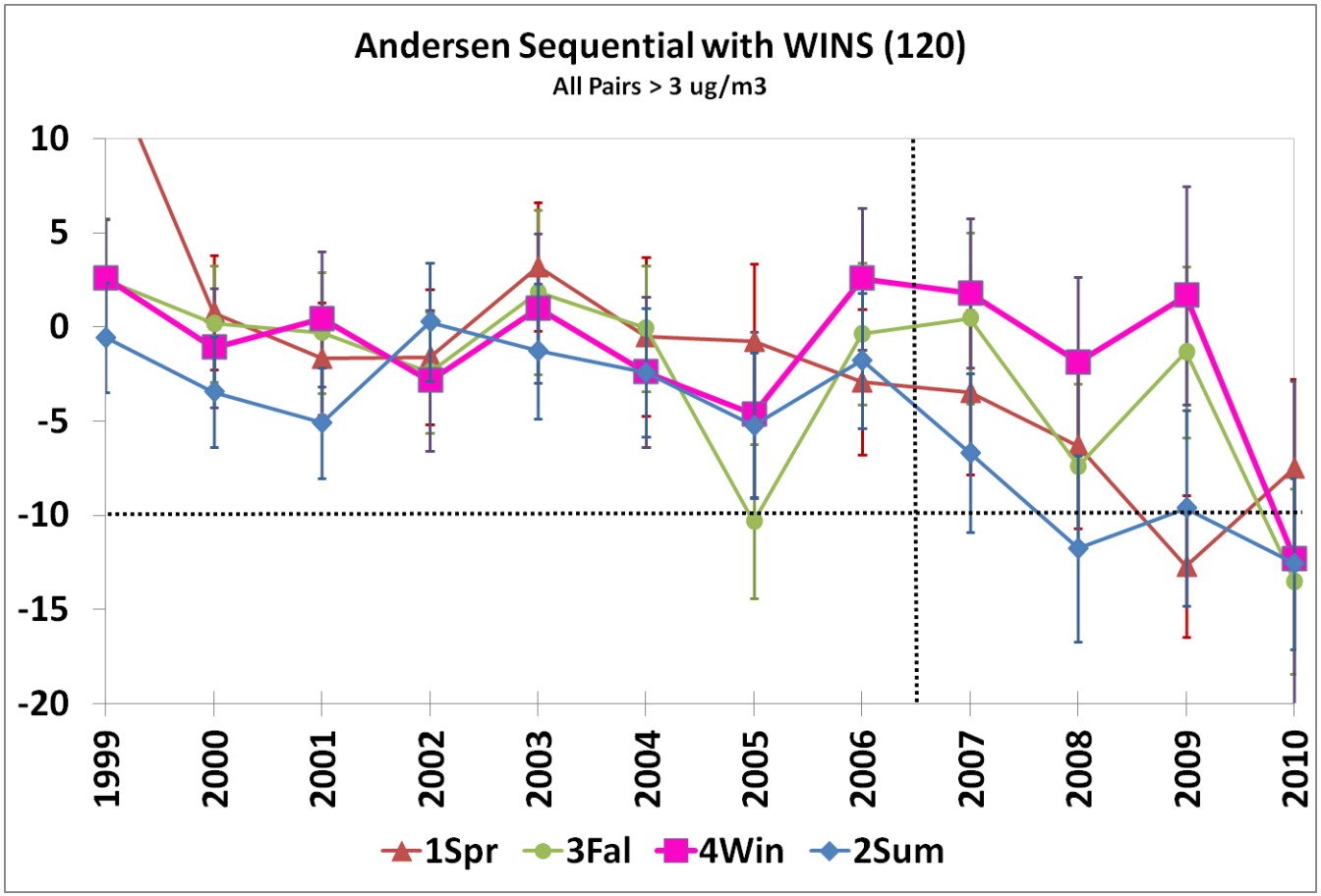
Estimates based on pairs > 3 µg/m^3.

Excludes |% diff| > 50%.

Excludes SLTValues =0 µg/m^3.

Question 5 – Has Bias Been Changing Over Time by Season?

YES. All seasons trending down, starting in 2007.



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PQAO-Season bias estimates.

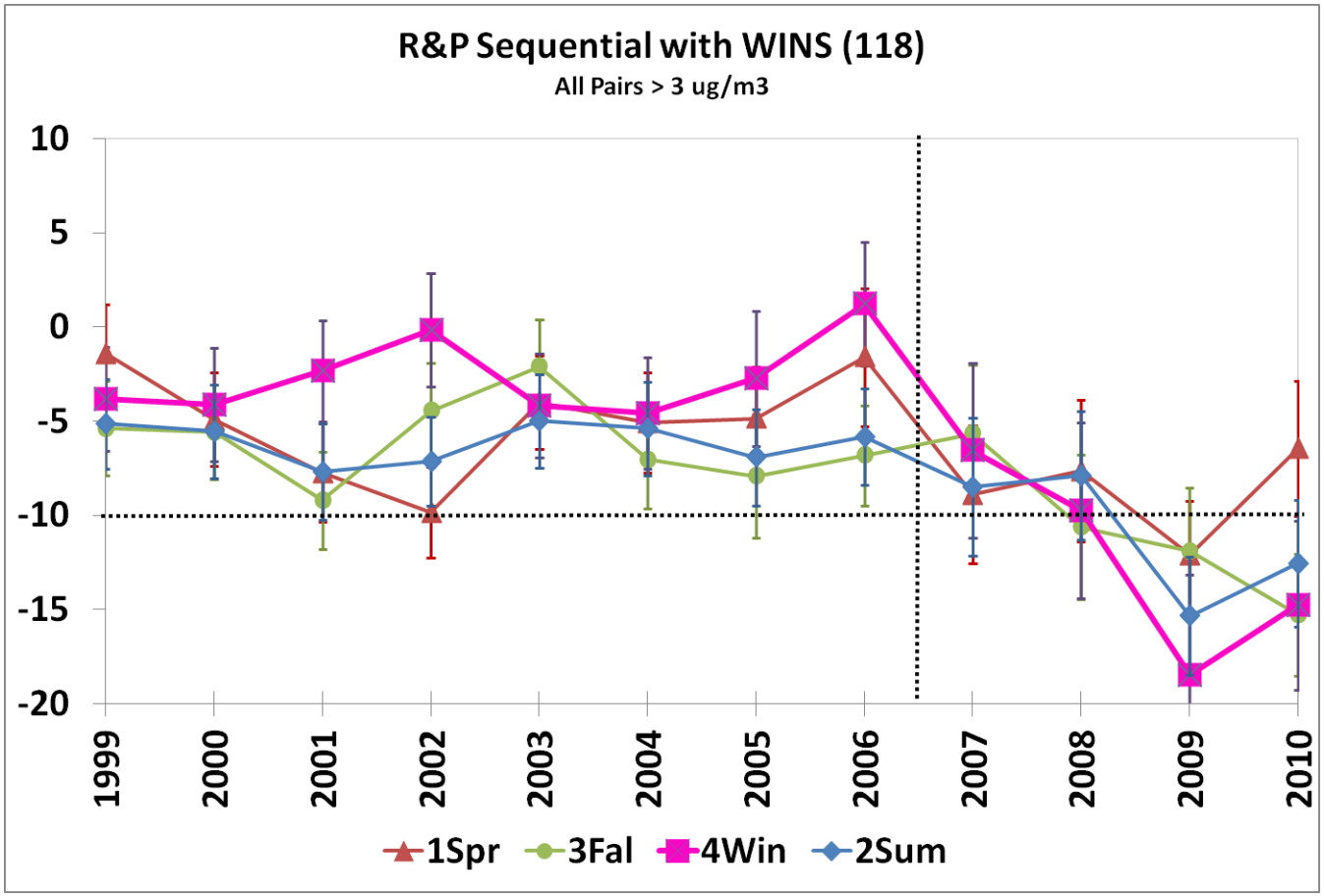
Estimates based on pairs > 3 µg/m^3.

Excludes |% diff| > 50%.

Excludes SLTValues = 0.

Question 5 – Has Bias Been Changing Over Time by Season?

For Method 118, Winter trending down fastest.



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PQAO-Season bias estimates.

Estimates based on pairs > 3 µg/m^3.

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Excludes SLTValues = 0.

Questions 6 and 7

- Does Bias Vary by Region of the Country?
  - Not in any clear pattern.
  - Biases trending down across nation.
- Does Bias Vary by $PM_{2.5}$ Concentration?
  - No. Median bias by concentration is fairly stable.
  - Spread in bias increases as concentrations decrease.

Puzzling Questions

- Why did biases start to drop in 2007?
  - It is not the switch in SLT from WINS to VSCC.
  - It is not the switch in PEP from WINS to VSCC.
  - What is causing SLT Values to pull away from PEP Values?
- Why are all methods producing negative biases since 2007?
  - Prior to 2007, some methods positive, some negative.
- Why the inconsistency with WINS vs. VSCC for BGI Single Channel Samplers?
  - If PEP runs samplers, bias from WINS and VSCC similar.
  - If SLT runs samplers, bias from WINS more negative than bias from VSCC.

Next Steps

Additional questions to look into:

- Do ambient temperatures play a role? As temperature increases, does bias become more negative?
- Do changes in speciation of $PM_{2.5}$ play a role? As $PM_{2.5}$ concentrations come down, is the volatile fraction of $PM_{2.5}$ increasing?
- Do filters retrieved within 10 hours of the end of sampling have smaller bias than those retrieved after filter experiences heat of day?
- What is effect on bias of length of time between last WINS cleaning and sample collection? Do longer times mean lower concentrations?

People Behind the Curtain

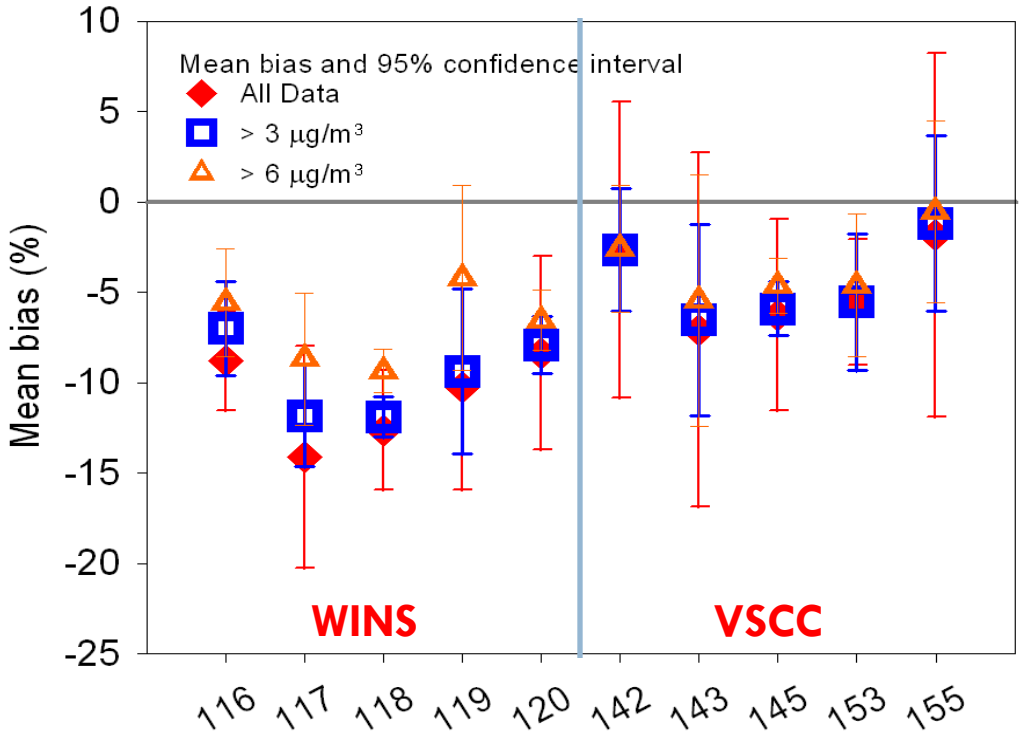
- EPA
  - Mike Papp
  - Dennis Crumpler
  - Lewis Weinstock
  - Tim Hanley
  - Bill Frietsche
- STI
  - Theresa O'Brien
  - Bryan Penfold

Sonoma Technology, Inc.

Slides for Reference as Needed

Question 4 – Does Bias Vary by Type of Separator for SLT?

Yes. When there are sufficient data, bias from WINS is more negative than bias from VSCC.



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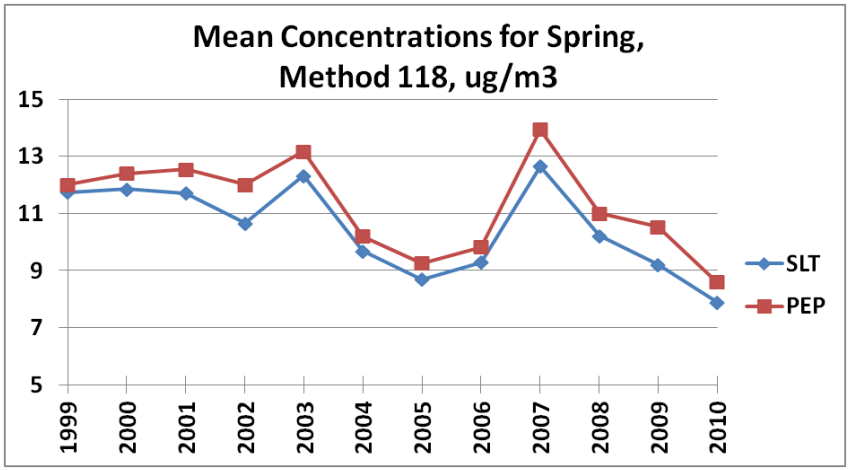
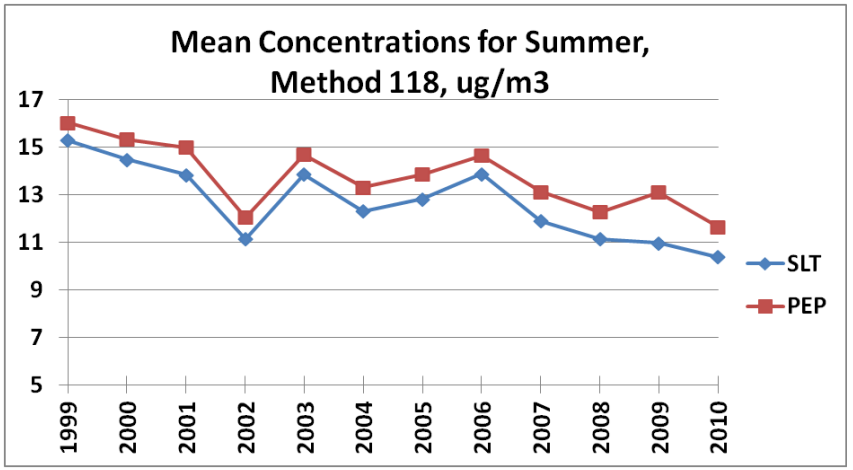
Statistical results based on Mann-Whitney Test of

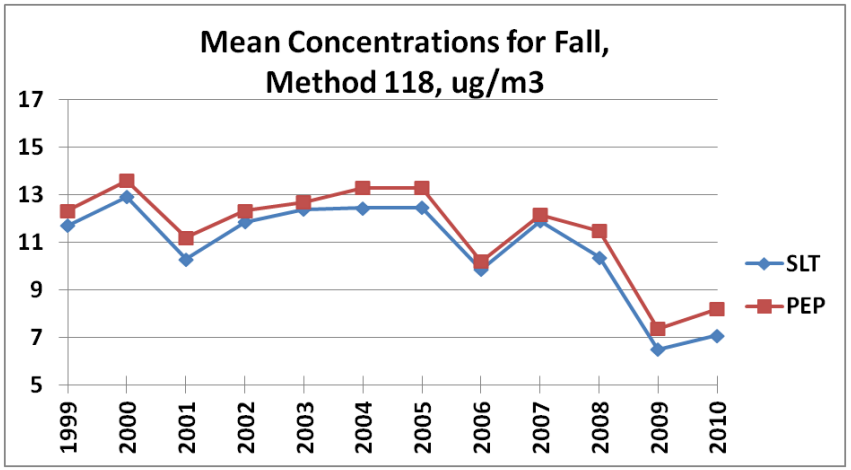
PQAO-season bias estimates, excludes |% diff| > 50%, excludes SLTValue=0, based on 2008-2010 data, based on pairs > 3 µg/m³, test at alpha=0.10.

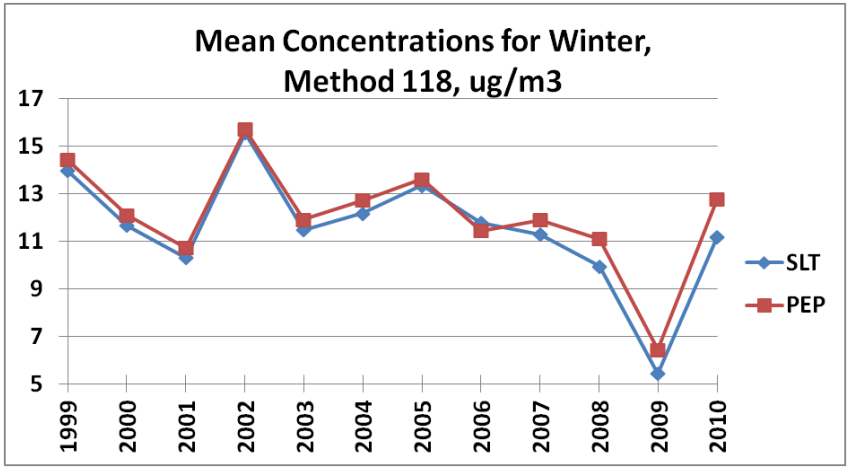
Question 5 – A Closer Look at Bias by Season over Time for Method 118

For Method 118, in 2007-2008, the spread between SLT and PEP increased in all seasons and has not returned to pre-2007 levels.



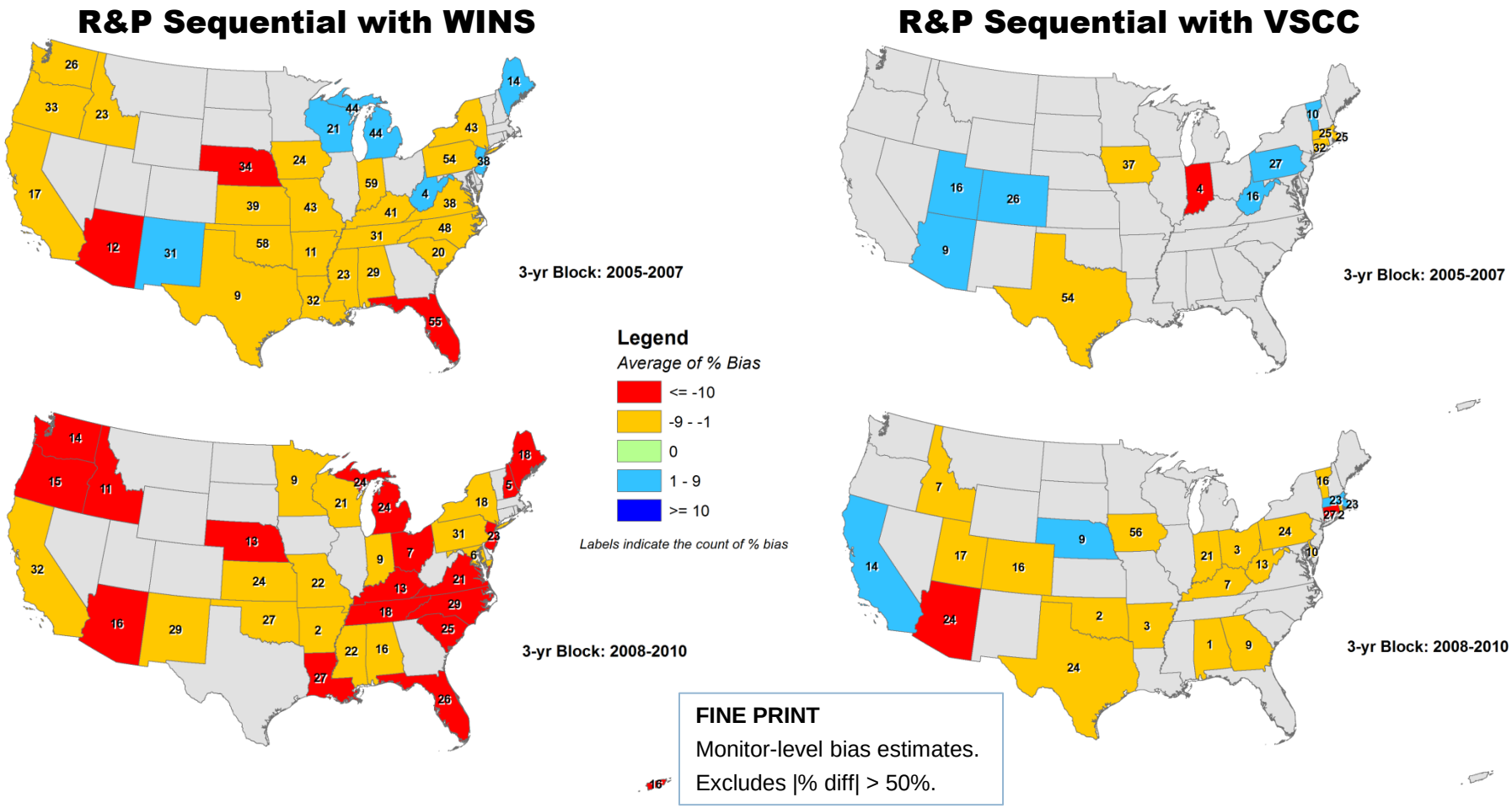






Question 6 – Does Bias Vary by Region of the Country?

Not clearly. But biases generally trending down nationwide.



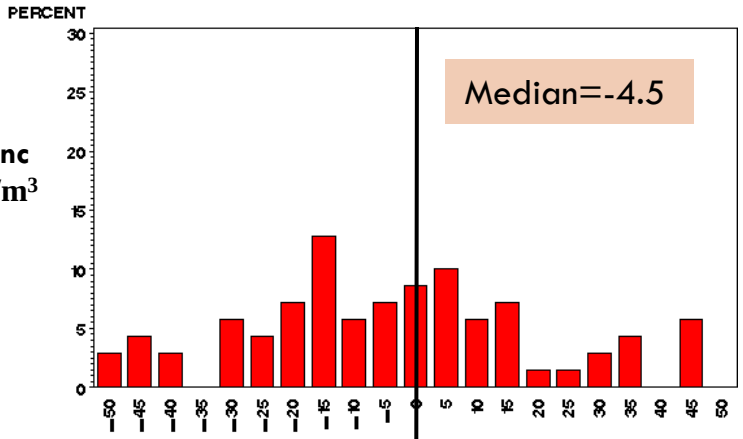
Question 7 – Does Bias Vary by $PM_{2.5}$ Concentration?

- The role of $PM_{2.5}$ concentrations appears minimal; it does not appear to explain the more recent trends in negative bias.
- **Spread** of bias decreases as concentration increases.
- However, what **central tendency (median)** does depends on years analyzed.
  - Bias data from 2004-2006 suggest no association between $PM_{2.5}$ concentration and bias.
    - Median bias distributed similarly for various $PM_{2.5}$ concentration bins.
  - Bias data from 2008-2010 suggest no or limited association between $PM_{2.5}$ concentration and bias.
    - Median bias closer to 0 $\mu g/m^3$ for concentrations > 12 $\mu g/m^3$.
    - However, below 12 $\mu g/m^3$, there is no association between $PM_{2.5}$ concentration and bias.

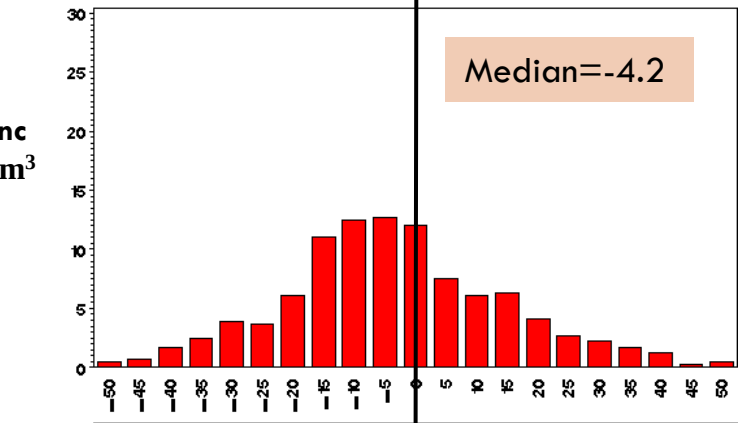
FINE PRINT
Monitor-level bias estimates.
Excludes |% diff| > 50%.
Excludes SLTValue=0.

Percent Bias from 2004-2006

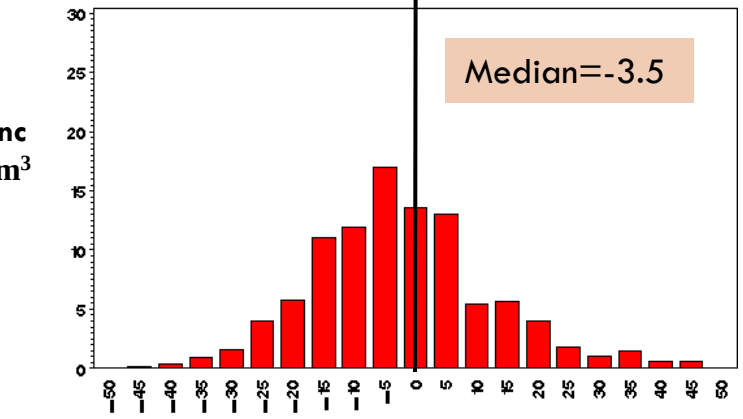
PEP Conc
0-3 µg/m^3



PEP Conc
3-6 µg/m^3

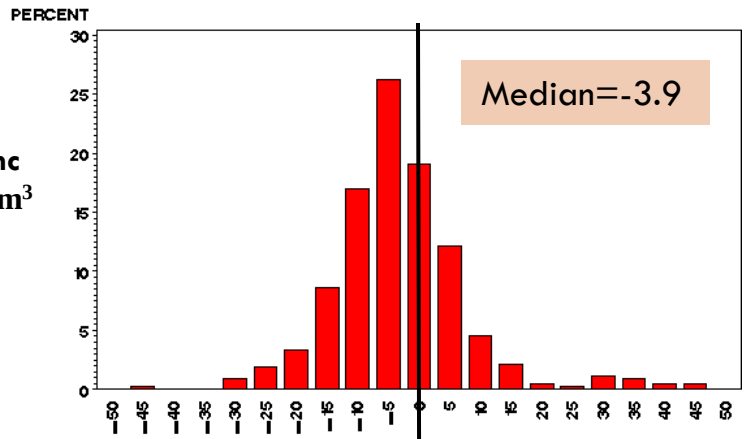


PEP Conc
6-9 µg/m^3

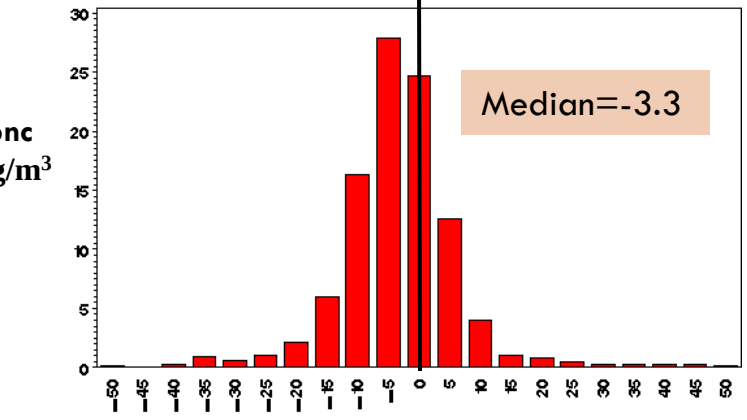


Percent Bias from 2004-2006

PEP Conc
9-12 µg/m^3

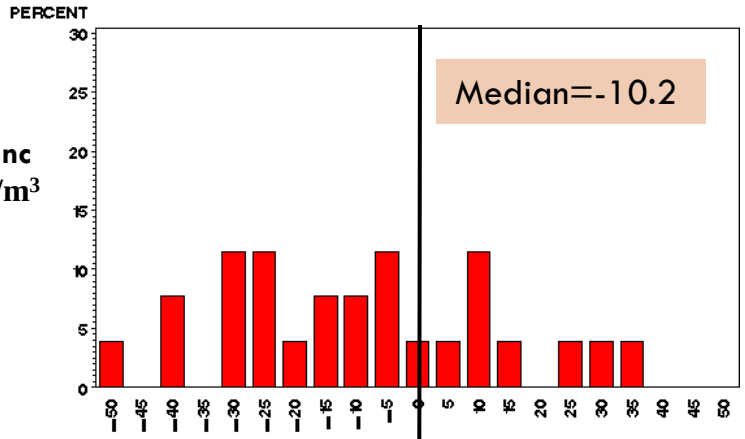


PEP Conc
> 12 µg/m^3

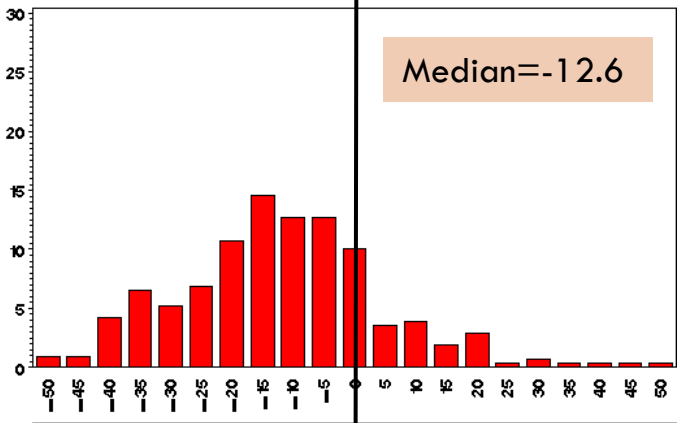


Percent Bias from 2008-2010

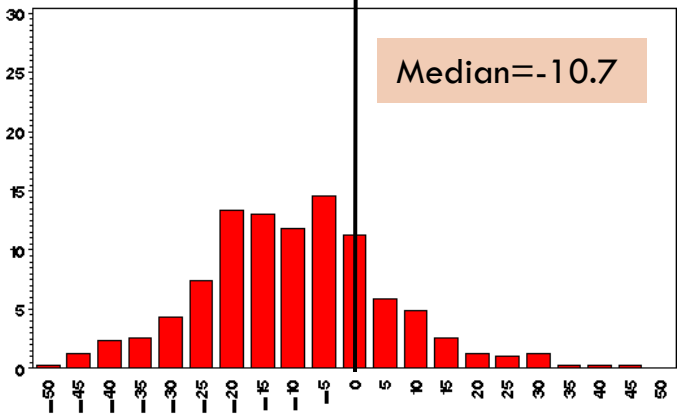
PEP Conc
0-3 µg/m^3



PEP Conc
3-6 µg/m^3

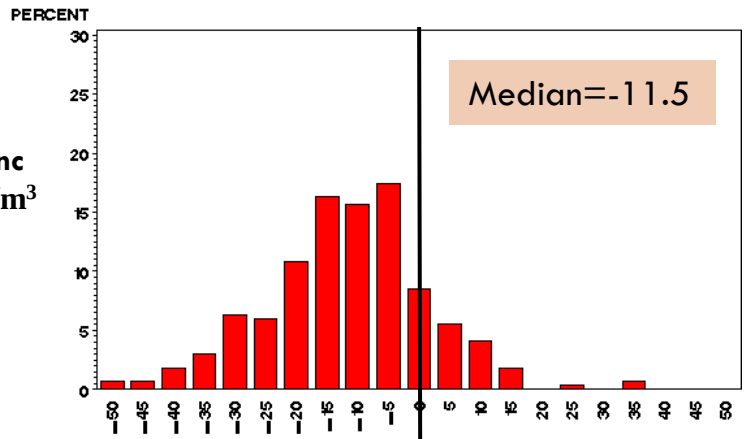


PEP Conc
6-9 µg/m^3



Percent Bias from 2008-2010

PEP Conc
9-12 µg/m^3



PEP Conc
> 12 µg/m^3